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(54) APPARATUS FOR TRANSFER OF HEAT ENERGY

(71) We, DORNIER SYSTEM G.m.b.H., a German limited liability company, of 7990 Friedrichshafen, Postfach 648, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for transfer of heat energy by evaporation of a medium and return of condensate by capillary action.

In such an apparatus, when heat is supplied at one end of it, liquid medium, by virtue of the temperature drop along the apparatus, flows to the other colder end thereof, where it condenses, giving off evaporation heat. The condensate flows by capillary action in counter-current, back from the colder end to the heat source.

With appropriate design, such apparatus can be operated independently of gravity and/or the action of mass acceleration and vibration, and may thus be used in space, where there is no gravity.

If such apparatus is to be integrated into a sandwich structure and if the sandwich structure is also to support for instance electronic components whose temperature is to be influenced, the transport of heat energy and the return conveyance of condensate to achieve isothermal conditions in the sandwich structure, can only be approximately brought about by the provision of individual heat pipes or by a complicated system of connected heat pipes. The requirement that a sandwich structure should provide isothermal conditions can also be fulfilled by a complicated integral construction in which capillary grooves are machined out of a wall material.

An object of the invention is to provide an apparatus for transfer of heat energy, by means of which virtually isothermal conditions can be achieved with quite rapid exchange of energy. According to this invention, there is provided apparatus for transfer of heat energy by evaporation of a medium and return of condensate by capillary action, wherein:—

i) the apparatus is of sandwich construction with walls enclosing a space in which are honeycomb cells;

ii) the cells are of close-mesh net material and adapted to convey the condensate;

iii) the cells are connected to the walls by a sintered layer between the cells and each wall; and

iv) the layers are of a material chemically compatible with the medium.

The sintered layer between walls and cells permits condensate return in the direction of the plane of the walls by capillary action over the shortest distance from the heat sink to the heat source. In consequence, friction losses are reduced compared with an apparatus whose parts are connected by adhesive, and thus operating capacity is increased. At the same time, the sintered layers provide a firm connection between walls and cells. By using the sintered layers, in contrast to layers of adhesive, the range of application of filling media, determined by chemical compatibility between the medium and the sandwich structure, is widened, since chemical decomposition can give rise to deterioration of the apparatus. In some circumstances an apparatus, in which layers of adhesive are used, will age more rapidly, so that the operating capacity is reduced and the temperature curve is impaired. Also loss of rigidity may result in failure of the apparatus.

An apparatus constructed in accordance with the invention can advantageously also be used as a structural support, for example in a nose cone or satellite casing. The heat energy can be transported for example from

a zone of a satellite casing on which the sun's rays fall to a zone which is in shade and there be irradiated into space. To prevent failure of the apparatus, e.g. in the event of collision with a meteorite, it is also possible to form a satellite casing from several intercoupled but independently operating apparatuses according to the invention.

The invention will now be described by way of example, with reference to the attached drawing, in which:—

Figure 1 is a cross-section on line I-I of Figure 2, showing the apparatus forming a support for an electronic component; and

Figure 2 is a perspective view partly broken away and in section along the plane A-A of Figure 2.

Referring to the drawing there is shown an embodiment of the apparatus in the form of a support for an electronic component, the temperature of which is to be influenced. The apparatus is a sandwich structure.

Reference numeral 1 denotes the entire apparatus for transfer of heat energy. The apparatus has enclosing walls in conjunction with a honeycomb structure. There are upper and lower enclosing walls 3, 4 and lateral enclosing walls 6 of which only one is shown and is of U-section. These walls form a closed space which constitutes a working space containing honeycomb cells 10 in hexagonal arrangement, as shown in Figure 2. The cells are of a net-like material and form a capillary system so as to return condensate from a heat sink to a heat source of the apparatus in a 3-directional manner (arrows X, Y and Z). Referring to Figure 2 Q_H is the heating zone and Q_K is the cooling zone, related to the transport of energy in the direction of the arrow X. The direction of vapour flow in the honeycomb cells is indicated by continuous solid arrows D and condensate return by broken-line arrows K and by arrows K′ in sintered layers 20, 20′. Each cell 10 has apertures 11 for passage of liquid which is evaporated in the heating zone. Through the apertures 11, the evaporated liquid can flow in the direction of the arrows X and Y from the heat source to the heat sink. In the direction of the arrow Z, the evaporated liquid can spread out within the spaces 13 in the honeycomb cells. The cells 10 are connected at their top and bottom edges 15, 16 to the walls 3, 4. This connection is by the sintered layer 20 which extends over the entire inner faces of the walls 3, 4 and which is of a material compatible with the liquid medium. In the same way, between the cells 10 and the walls 6 there is a sintered layer 20′ of like material.

In the region of their upper and lower edges 15, 16 the cells 10 are bent out at right angles to achieve better connection to the walls 3, 4 by the sintered layers 20.

In Figure 2, an electronic component 22 is supported by the apparatus 1. The apparatus 1 has a bush 23 which is connected to the adjacent honeycomb cells by a sintered layer 20″ of the same material as the layers 20 and 20′. The sintered layer 20″ serves for localised distribution of the condensate. The component is screwed to the bush 23. For firm connection between the bush 23 and the walls 3, 4 there are, in addition to the sintered layer 20″, vacuum-tight and pressure-tight welds 25. Similar welds 26 are disposed between the side walls 6 and the walls 3, 4.

The condensate in the space enclosed by the walls 3, 4 and 6 is evaporated in the region of the heating zone Q_H when the closed space within the apparatus 1 is evacuated, and flows in the direction of the arrows D through the apertures 11 to the cooling zone Q_K, which may be connected to a cooling heat sink or radiator (not shown). For clarity, only one heating zone Q_H and one cooling zone Q_K are shown, in the X direction of the apparatus. The evaporated liquid condenses, giving off evaporation heat to the cooling zone Q_K and the condensate is for the most part returned by capillary action in the sintered layers 20, 20′ (arrow K′) in the X direction to the heating zone Q_H. A relatively small quantity of condensate is likewise returned to the heating zone Q_H by other than a straight route, by capillary action of the reticular cell structure. A local wetting of the capillary structure by the condensate according to the arrows Z and Y in both directions, in other words at right angles to the main X direction of flow, is ensured within the apparatus, so that local drying out of the capillary structure with a rapid rise in temperature is avoided. By reason of the sintered layer 20′ and cells 10, condensate distribution in the Z direction (arrows K′ and K respectively) and thus a connection with the flows of condensate K′ in the sintered layers 20 of the walls 3 and 4 are achieved at the same time. Likewise, condensate distribution in the Y direction (arrows K, K′) will occur in the cells 10 and sintered layer 20.

The main direction of heat energy transport and return of condensate can take place both from one wall 3 or 4 to the other in the Z-direction and also in the Y-direction, according to the arrangement of the electronic components on the apparatus and also according to the relative positions of the hot and cold zones. If the main direction of heat energy transport is of equal magnitude in all three axes (X, Y and Z) wetting of all the capillary structures by the condensate is possible. Accord-

ing to the disposition of the cooling and heating zones, therefore, heat energy transport or condensate return will take place in the three directions Z, X and Y. By reason of the sintered layers 20, 20′ condensate return, in conjunction with the reticular honeycomb cell structure, is substantially enhanced so that increased heat transfer capacity is achieved. At the same time, by virtue of the sintered layers 20, 20′ and 20″, rigid connection is established between the cells 10 and the walls 3, 4 and 6 and the bush 23. Further, condensate is returned through the sintered layers 20, 20′ from the heat sink (Q_K) to the heat source (Q_H) by the shortest route.

WHAT WE CLAIM IS:—

1. Apparatus for transfer of heat energy by evaporation of a medium and return of condensate by capillary action, wherein:—

i) the apparatus is of sandwich construction with walls enclosing a space in which are honeycomb cells;

ii) the cells are of close-mesh net material and adapted to convey the condensate;

iii) the cells are connected to the walls by a sintered layer between the cells and each wall; and

iv) the layers are of a material chemically compatible with the medium.

2. Apparatus according to claim 1, wherein the upper and lower edges of the cells are bent at right angles to the remainder of the cells for connection to the layers.

3. Apparatus for transfer of heat energy constructed and arranged substantially as herein described and shown in the accompanying drawing.

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1,402,509 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.

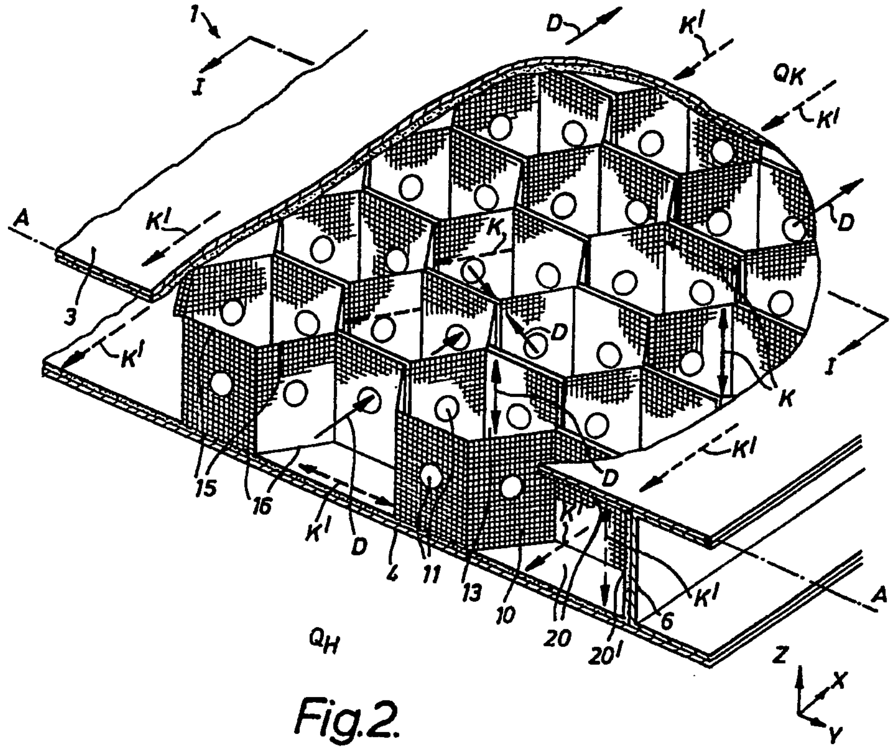

Fig.2.

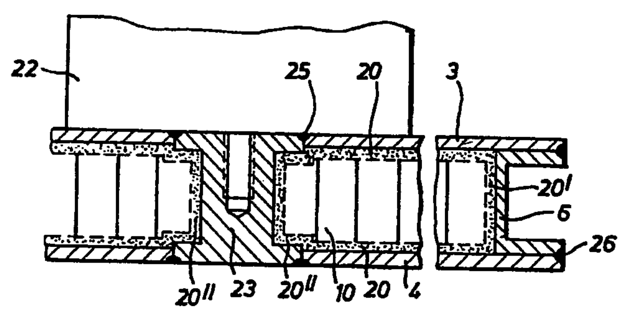

Fig.1.